Fisheries and Oceans Science | Pêches et Océans Sciences

CSAS | **SCÉS**

Canadian Stock Assessment Secretariat | **Secrétariat canadien pour l'évaluation des stocks**

Research Document 2000/094 | **Document de recherche 2000/094**

Not to be cited without Permission of the authors [1] | Ne pas citer sans autorisation des auteurs [1]

Relative strength of the 1999 year-class, from nearshore surveys of demersal age 0 Atlantic cod in 3KL and in Newman Sound, Bonavista Bay

Robert S. Gregory, David A. Methven, Laura A. Wheeler, David C. Schneider, and Joseph A. Brown

Memorial University of Newfoundland,
Ocean Sciences Centre,
St. John's, Newfoundland, Canada
A1C 5S7

[1] This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

[1] La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au Secrétariat.

This document is available on the Internet at: Ce document est disponible sur l'Internet à:
http://www.dfo-mpo.gc.ca/csas/

ISSN 1480-4883
Ottawa, 2000
Canada

Abstract

From 1959 to 1964 and 1992 to 1997 (i.e., 1990s), demersal age 0 Atlantic cod (*Gadus morhua*) in the nearshore (<10 m deep) were surveyed by seine from St. Mary's Bay to Notre Dame Bay, Newfoundland during the Fleming survey, conducted annually in September and October. In the absence of a coastwide Fleming survey in 1998 and 1999, we conducted a qualitative assessment of the strength of the 1997, 1998, and 1999 year-classes based on abundance of demersal age 0 and age 1 Atlantic cod sampled at 6 - 13 nearshore sites in Newman Sound, Bonavista Bay in the summer and autumn in 1995, 1996, 1998, and 1999. Sampling techniques and collection dates for the Fleming survey and Newman Sound study were similar. Therefore, cod abundances in the two studies were comparable, albeit at different geographic scales. Abundance trends of age 0 and 1 cod covaried between the studies in 1995 and 1996, when both were conducted concurrently, suggesting that abundances of juvenile cod in Newman Sound mirrored those observed in the spatially broader Fleming survey. In 1997, age 0 abundance in the Fleming survey was the highest observed in the 1990s, leading to the prediction that age 1 cod would be high the following year. High age 1 abundance in 1998 compared to 1995 and 1996 in Newman Sound supported this prediction. Compared with the historical low in 1996 observed in both studies, age 0 abundance was 10 times higher in 1998 and 40 times higher in 1999. These results suggest that the 1997, 1998, and 1999 year classes should be strong compared to those in 1995 and 1996. Analysis of length frequency data collected from July to November in Newman Sound indicated that age 0 Atlantic cod settled in the nearshore in two distinct recruitment pulses in "good years" - i.e., 1998 and 1999 - the first pulse arriving in early August, the second in late September. In "bad years" - i.e., 1995 and 1996 - only the second of these pulses was evident. The length frequency data also suggest that the pulse structure may remain intact through the first winter and be detectable in age 1 cod the subsequent year. We predict that the 1999 year class of Atlantic cod will be the strongest since the 1992 moratorium.

Résumé

De 1959 à 1964 et de 1992 à 1997 (années 1990), un relevé à la senne des morues de l'Atlantique (Gadus morhua) démersales d'âge 0 se trouvant à proximité de la côte (<10 m de profondeur) a été effectué à St. Mary's Bay à la baie Notre Dame, à Terre-Neuve, pendant le relevé Fleming qui est réalisé à chaque année en septembre et octobre. Le relevé Fleming n'ayant pas été effectué à la grandeur de la côte en 1998 et 1999, nous avons procédé à une évaluation qualitative de l'importance des classes d'âge de 1997, 1998 et 1999 en nous fondant sur l'abondance des morues démersales d'âges 0 et 1 prélevées dans 6 à 13 sites voisins de la côte dans le Newman Sound, Bonavista Bay, au cours de l'été et de l'automne de 1995, 1996, 1998 et 1999. Les techniques et les dates de prélèvement utilisées pour le relevé du Newman Sound étaient semblables à celles du relevé Fleming. Les abondances de ces deux relevés étaient donc comparables, bien qu'à des échelles géographiques différentes. Les tendances de l'abondance des morues d'âges 0 et 1 des relevés de 1995 et 1996, effectués simultanément, présentaient des allures de covariables, ce qui porte à croire que l'abondance des morues juvéniles notée pour Newman Sound reflétait celle observée au cours du relevé Fleming, de plus grande envergure. En 1997, l'abondance des âges 0 notée au moment du relevé Fleming était la plus élevée des années 1990, de sorte que celle des morues d'âge 1 devrait être élevée l'année suivante. L'abondance élevée des morues d'âge 1 en 1998, comparativement à celles des années 1995 et 1996 dans Newman Sound confirme cette prévision. Comparativement aux faibles valeurs historiques notées pour 1996 au moment des deux relevés, l'abondance des âges 0 était 10 fois supérieure en 1998 et 40 fois supérieure en 1999. Ces résultats portent à croire que les classes de 1997, 1998 et 1999 devraient être importantes par rapport à celles de 1995 et de 1996. L'analyse des données de fréquences des longueurs obtenues de juillet à novembre dans Newman Sound montre que les morues de l'Atlantique d'âge 0 se sont fixées dans la zone côtière en deux poussées de recrutement distinctes au cours des « bonnes » années de 1998 et 1999 – la première arrivant au début d'août et la seconde à la fin septembre. Au cours des « mauvaises » années de 1995 et 1996, seule la seconde de ces poussées était décelable. Les données de fréquences de longueurs indiquent aussi que cette structure des poussées peut demeurer intacte après le premier hiver et être décelable chez les morues d'âge 1 l'année suivante. Nous prévoyons que la classe de 1999 de morue de l'Atlantique sera la plus importante depuis l'imposition du moratoire, en 1992.

Introduction

It has been shown, at least for the 1990's, that age 0 and age 1 Atlantic cod in 3KL (Northeast Newfoundland Shelf) are distributed predominantly in inshore waters (Dalley & Anderson 1997). Within these inshore waters during autumn, age 0 cod are most common in shallow water in the nearshore (<10 m deep - Methven & Schneider 1998, Gregory et al. submitted). The Fleming surveys (1959 - 64, Lear et al. 1980; 1992-97, e.g., Methven et al. 1998) have historically sampled nearshore abundances of age 0-2 Atlantic cod, with the objective of assessing relative year-class strength. These surveys have generally been successful at predicting the relative strength of adjacent cohorts through the first years of life (Schneider et al. 1997).

The 1997 Fleming survey (Methven et al. 1998) reported the highest abundance of age 0 cod in the nearshore during the 1992 to 1997 period. However, the success (or failure) of the both the 1997 year-class and the subsequent 1998 year-class, could not be assessed directly as the Fleming survey was not conducted in 1998 or 1999.

Fortunately, we have access to nearshore abundance data similar to the Fleming time series in a small area within the region sampled annually by that survey. In Fall 1995, an investigation of the adundance of age 0 cod and their association with nearshore habitat types was initiated in Newman Sound, Bonavista Bay (Gotceitas et al. 1996). The 1995 study was followed by similar efforts in 1996 (Gregory et al. 1997), 1998 (Gregory et al. 1999) and 1999. These studies showed that the nearshore of Newman Sound represents a significant nursery area for demersal age 0 Atlantic cod. The Newman Sound studies were conducted using the same sampling techniques as the Fleming surveys; collection dates also overlapped. Therefore, the abundance data of the two surveys during the period of study were comparable, albeit at different spatial scales.

In this study, we qualitatively assessed the relative strength of the 1999 year-class based on abundance of demersal age 0 and age 1 Atlantic cod in the nearshore in Newman Sound, Bonavista Bay in summer and fall 1999. We compared abundances of age 0 and age 1 Atlantic cod in Newman Sound in 1999 to previous years (1995, 1996, and 1998), linking interannual abundance trends to those demonstrated in the Fleming surveys (1992 - 97). We show that interannual trends between the Newman Sound data and the larger scale Fleming survey were consistent. This consistency allowed us to conclude two things: first, the 1998 and 1999 year-classes were relatively stronger than the 1995 and 1996 year-classes; and second, the strong 1997 year-class predicted as a result of the 1997 Fleming survey (Methven et al. 1998) was supported. We also present evidence that links age 0 abundance to temporal recruitment patterns within years. We suggest that in years of relatively higher recruitment, settlement occurs in more than one recruitment pulse (Methven and Bajdik 1994, Grant and Brown 1998) several weeks apart; in years of relatively poor recruitment, recruitment is often limited to a single pulse.

Methods

Sites sampled during the 1992 - 1997 Fleming surveys have been described in previous reports (e.g., Methven et al. 1998). In the 1990's, the Fleming survey was conducted at between 37 - 45 nearshore sites extending from St. Mary's Bay in the south to Notre Dame Bay in the north from 19 September to 27 October. In Bonavista Bay, sampling during the Fleming survey was generally 5 - 9 October (18 October in 1997).

Newman Sound seine sites (Fig. 1), described in Gregory et al. (1997), were selected on the basis of sampling logistics, and were similar to those of the Fleming survey (Lear et al. 1980). To maintain consistency among years, we have presented age 0 and age 1 abundance data from four of these sites (#1, 2, 3, and 6, Fig. 1), which were in common among our field programs in all years, 1995 - 99 in Newman Sound. For comparison with the Fleming survey data, we analyzed data from Newman Sound which had been collected only during the first two weeks of October during these years. In order to investigate seasonal growth and timing of recruitment pulses, we examined sizes of Atlantic cod captured and measured from all sites sampled in Newman Sound - September to November, 1995 (6 sites) and July to November in 1996 (9 sites), 1998 (13 sites) and 1999 (13 sites).

Both the Fleming survey and Newman Sound studies used the same sampling techniques. Fish samples were collected using a 25 m beach seine -- wings and belly 19 mm stretch mesh, codend 9 mm stretch mesh bag; 24.4 m headrope, 26.2 m footrope; 75 cm long and 25 mm diameter aluminum poles on each wing served to maintain the spread between the headrope and footrope. The net was deployed from a 6 m boat at a distance of 55 m from the shore, and then retrieved by two individuals standing 16 m apart on the shore. The seine was pulled along the bottom and sampled the lowest 2 m of the water column. Deployed in this manner, the net samples approximately 880 m^2 of the bottom. Less than 5% of all fish enclosed by the net are missed or escape (D.Ings, Memorial University of Newfoundland, unpublished data).

All fish collected were identified and counted. Juvenile cod were assigned to tentative age groups based on previously established age-length relationships in Newfoundland waters in late autumn (age 0: $\leq$ 10 cm SL [standard length], age 1: 10 to 20 cm SL, and age 2: 20 to 30 cm SL - Dalley & Anderson 1997).

Results and Discussion

We observed good correspondence of age 0 and age 1 Atlantic cod abundance trends in 1995 and 1996 between the Fleming survey and the Newman Sound study. In both studies, 1996 showed the lowest age 0 abundance among years (Fig. 2). Newman Sound abundance in 1996 was only 26% of that in 1995; in comparison, Fleming survey abundance in 1996 was 51% of that in 1995. Similarly, age 1 abundance was higher in 1996 than it had been in 1995 in both the Fleming survey (2.0 times higher) and in Newman Sound (2.4 times higher) data sets (Fig. 3). The results of the 1997 Fleming survey led Methven (1998) to predicted that age 1 abundance in 1998 would be higher than in previous years of the Fleming survey in the 1990s. Age 1 abundance observed in Newman

Sound in 1998 was higher than in 1995 and 1996 qualitatively supporting this prediction (Fig. 3). Age 0 Atlantic cod abundance in Newman Sound was over an order of magnitude higher in 1998 and 40-times higher in 1999 than in 1996. Abundance of age 0 Atlantic cod in 1996 was the lowest recorded in three independant prerecruit studies in the 1990s (1992-97 Fleming - Methven 1998, 1992-99 NE Newfoundland Shelf - Dalley et al. 2000, 1995-99 Newman Sound - this study). We suggest that the 1998 and 1999 year-classes will be strong relative to 1995 or 1996 year-classes, with the 1999 year-class being the strongest since the implementation of the 1992 moratorium.

Age 0 Atlantic cod appear to recruit (=settle) into nearshore habitats in a recruitment pattern consisting of a number of settlement pulses each year. Analysis of size distribution of age 0 Atlantic cod collected July to November in Newman Sound indicated that age 0 cod settled in only a single recruitment pulse in 1996 (Fig. 4). Similarly, we identified only a single Atlantic cod recruitment pulse in 1995 (Gotceitas et al. 1996), although sampling in Newman Sound only started in late September that year, making definitive statements regarding pulse structure somewhat tenuous. In contrast, in both 1998 (Fig. 5) and 1999 (Fig. 6) age 0 Atlantic cod recruited to the nearshore in two distinct recruitment pulses - the first arriving in August, the second in late September. In 1998, the first pulse was the strongest, whereas the two pulses were equally weighted in 1999 (Fig. 6). In Newman Sound, there was only one recruitment pulse in both 1995 (Gotceitas et al. 1996) and 1996 (Fig. 7), which were weak years for age 0 abundance overall. In contrast, there were two pulses in 1998 (Fig. 8) and 1999 (Fig. 9) - years of comparatively high age 0 abundance.

The pulse structure established for age 0 cod in any given year appears to have been maintained in the size structure of age 1 cod in the subsequent year. Evidence of a multiple pulse recruitment pattern was present in both 1996 (Fig. 7) and 1998 (Fig. 8). However, the evidence was especially compelling in 1999 (Fig. 9) when we examined data on the same year-class (1998) in two consecutive years - as age 0 in 1998 (Fig. 8) and as age 1 in 1999 (Fig. 9).

The ecological implications of multiple recruitment pulses on year-class strength has yet to be determined. The data in this study suggest that a complex pulse structure (e.g., two or more modes) may signal a relatively good recruitment year compared to a simple pulse structure (e.g., one mode). From genetic evidence, we do know that different stock components contributed differentially to each of these pulses in 1999 (Beacham et al. 2000). We do not yet know if the multiple recruitment patterns we observed in Newman Sound are restricted to individual sites. However, we do know that similar recruitment patterns occur annually at other sites along the northeast Newfoundland coast (Methven & Bajdik 1994, Grant & Brown 1998) suggesting that these observations reflect broader geographic phenomena. Although the ecological implications of complex recruitment pulse structure remain to be worked out, these implications could be large. Size-selective mortality factors should effect differential survival between individuals from different recruitment pulses (Sogard 1997).

Based on the results of this study, we make the following conclusions:

- we reinforce our prediction from 1999 (Gregory et al. 1999) that the 1998 year class will be strong relative to the 1995 and 1996 year classes;
- we continue to support the predictions of Methven et al. (1998) that the 1997 year-class will be strong relative to 1995 and 1996;

- we expect that overall recruitment of age 0 Atlantic cod will be weakest when there is weak recruitment pulse structure; and,
- we predict that the 1999 year-class will be the strongest in the last half of the 1990s.

Acknowledgements

This study was supported financially at various stages through a NSERC Strategic Projects grant, an award from the Environmental Innovations Program (EIP), and a contract to Parks Canada - Terra Nova National Park (TNNP), and by Department of Fisheries and Oceans by way of EIP. We are grateful for additional in kind support supplied by TNNP and DFO. Mr. Ted Potter (TNNP, now at DFO) is thanked for his support of this work at an early stage. This study could not have been conducted without the capable assistance in the field and laboratory of many students and technical staff at MUN, too numerous to list here. Dr. Vytenis Gotceitas is thanked for performing a critical piece of data archeology.

References

Beacham, T.D., R.S. Gregory, and J. Brattey 2000. Origins of two recruitment pulses of 0-group Atlantic cod (*Gadus morhua*) in Bonavista Bay, Newfoundland during 1999, determined from genetic variation. Can. Stock Assess. Secret. Res. Doc. 2000/093

Dalley, E.L. and J.T. Anderson. 1997. Distribution and abundance of demersal juvenile cod (Gadus morhua) in inshore and offshore areas of northeast Newfoundland (NAFO Divisions 3KL) in the early 1990's. Can. J. Fish. Aquat. Sci. 54(Suppl.1):168-176.

Dalley, E.L., J.T. Anderson and D.J. Davis. 2000. Year-class strength of northern cod (2J3KL) and southern Grand Banks cod (3NO) estimated from the pelagic juvenile fish survey in 1999. Can. Stock Assess. Secret. Res. Doc. 2000/096

Gotceitas, V., R.S. Gregory, and S. Fraser. 1996. Distribution of habitat types and fish in the nearshore environment of inner Newman Sound, Terra Nova National Park, Newfoundland, Canada. Memorial University of Newfoundland. 1995-96 Annual Progress Report to Terra Nova National Park, Project No. MEM95-001.

Grant, M.G., and J.A. Brown. 1998. Nearshore settlement and localization populations of age 0 Atlantic cod (*Gadus morhua*) in shallow coastal waters of Newfoundland. Can. J. Fish. Aquat. Sci. 55: 1317-1327.

Gregory, R.S., V. Gotceitas, S. Fraser, P. Lundrigan, and J.A. Brown. 1997. Temporal and spatial survey of the fish community and its distribution among nearshore habitat types in the marine environment in the vicinity of Terra Nova National Park. Final Report to Canadian Heritage-Parks Canada.

Gregory, R.S., D.A. Methven, D.C. Schneider, and D.W. Ings. 1999. Relative strength of the 1998 year-class, from nearshore surveys of demersal age 0 Atlantic cod in 3KL and in Newman Sound, Bonavista Bay. Can. Stock Assessment Secretariat Res. Doc. 99/44.

Gregory, R.S., S. Fraser, J.T. Anderson, and J.A. Brown. Submitted. Diel and spatial distribution of juvenile Atlantic cod in inshore and nearshore coastal waters of Newfoundland. J. Fish Biol.

Lear, W.H., A.M. Fleming, and R. Wells. 1980. Results of small cod surveys in eastern Newfoundland during 1959-64. NAFO SCR Doc. 80/144.

Methven, D.A., and C. Bajdik. 1994. Temporal variation in size and abundance of juvenile Atlantic cod (*Gadus morhua*) at an inshore site off eastern Newfoundland. Canadian Journal of Fisheries and Aquatic Sciences 51: 78-90.

Methven, D.A., and D.C. Schneider. 1998. Gear-independent patterns of variation in catch of juvenile Atlantic cod (*Gadus morhua*) in coastal habitats. Canadian Journal of Fisheries and Aquatic Sciences 55: 1430-1442.

Methven, D.A., D. C. Schneider, and D.W. Ings. 1998. Results of the 1997 Fleming Survey of demersal juvenile cod in the coastal zone of eastern Newfoundland. Memorial University, St. John's 26 p.

Schneider, D.C., P. Hennebury, D. Methven, D. Ings, and D. Pinsent. 1997. Fleming survey of demersal juvenile cod in coastal areas of eastern Newfoundland. NAFO Sci. Counc. Studies 29:13-21.

Sogard, S.M. 1997. Size-selective mortality in the juvenile stage of teleost fishes: a review. Bull. Mar. Sci. 60:1129-1157.

Figure 1. Location of sampling sites and nearshore habitat in Newman Sound, Bonavista Bay July to November 1995-99.

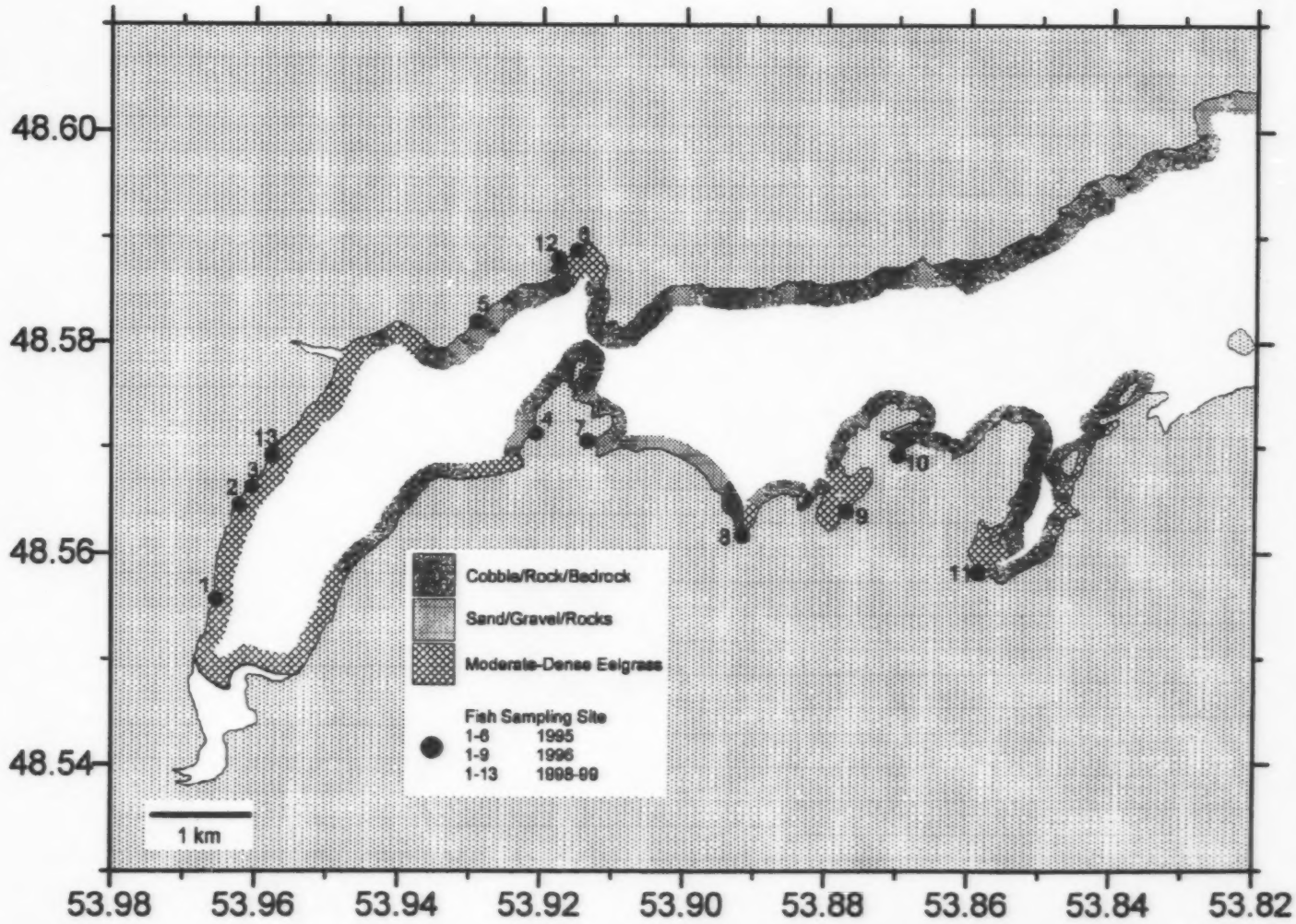

Figure 2. Mean age 0 Atlantic cod abundance (mean/set) caught by beach seine in the Fleming survey 1959-64 and 1992-97, St. Mary's Bay to Notre Dame Bay (upper panel) and in Newman Sound Bonavista Bay, 1995-99 (lower panel). Vertical bars are 95% confidence intervals estimated by randomized data resampling.

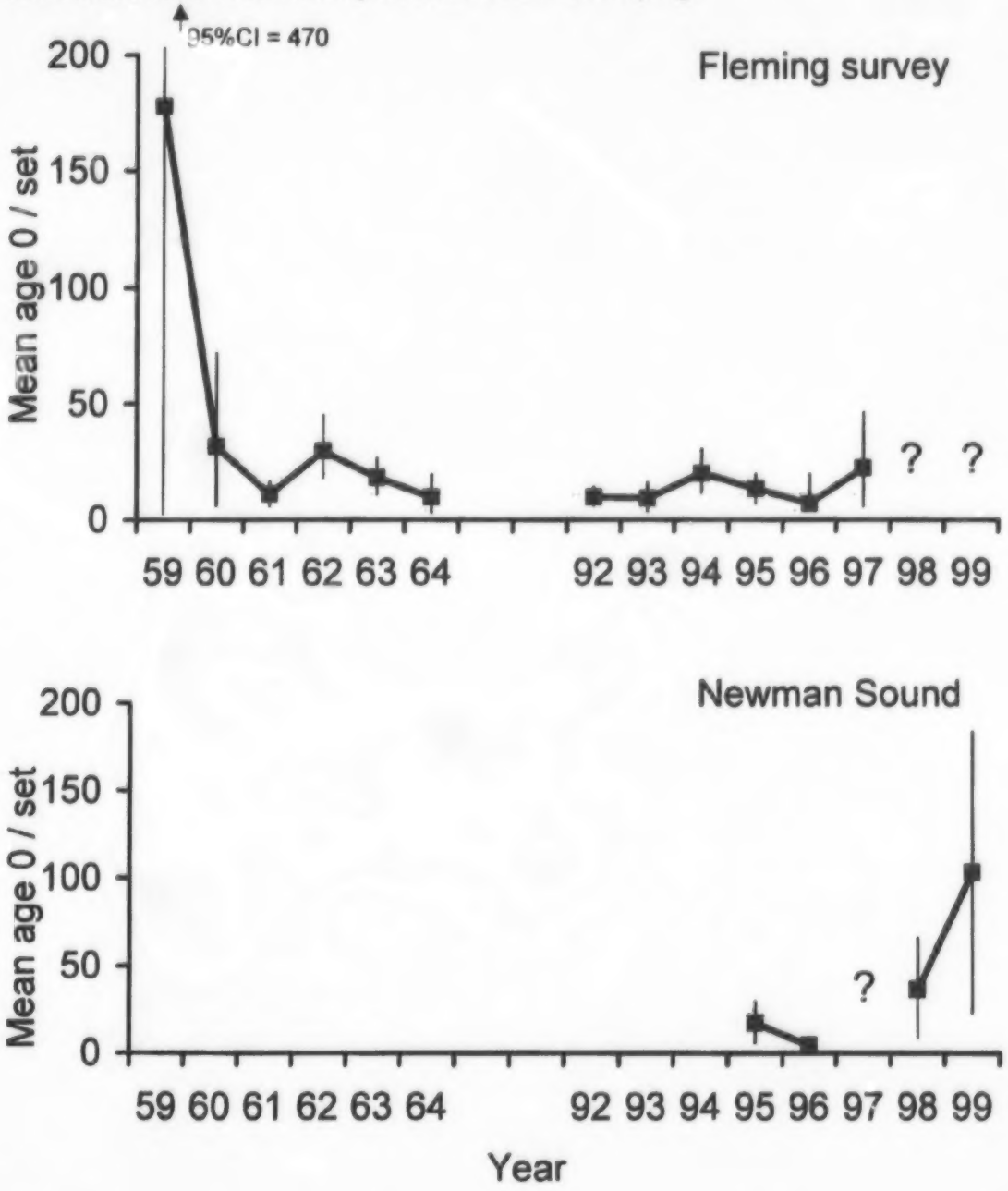

Figure 3. Mean age 1 Atlantic cod abundance (mean/set) caught by beach seine in the Fleming survey 1992-97, St. Mary's Bay to Notre Dame Bay (upper panel) and in Newman Sound Bonavista Bay, 1995-99 (lower panel). Vertical bars are 95% confidence intervals estimated by randomized data resampling.

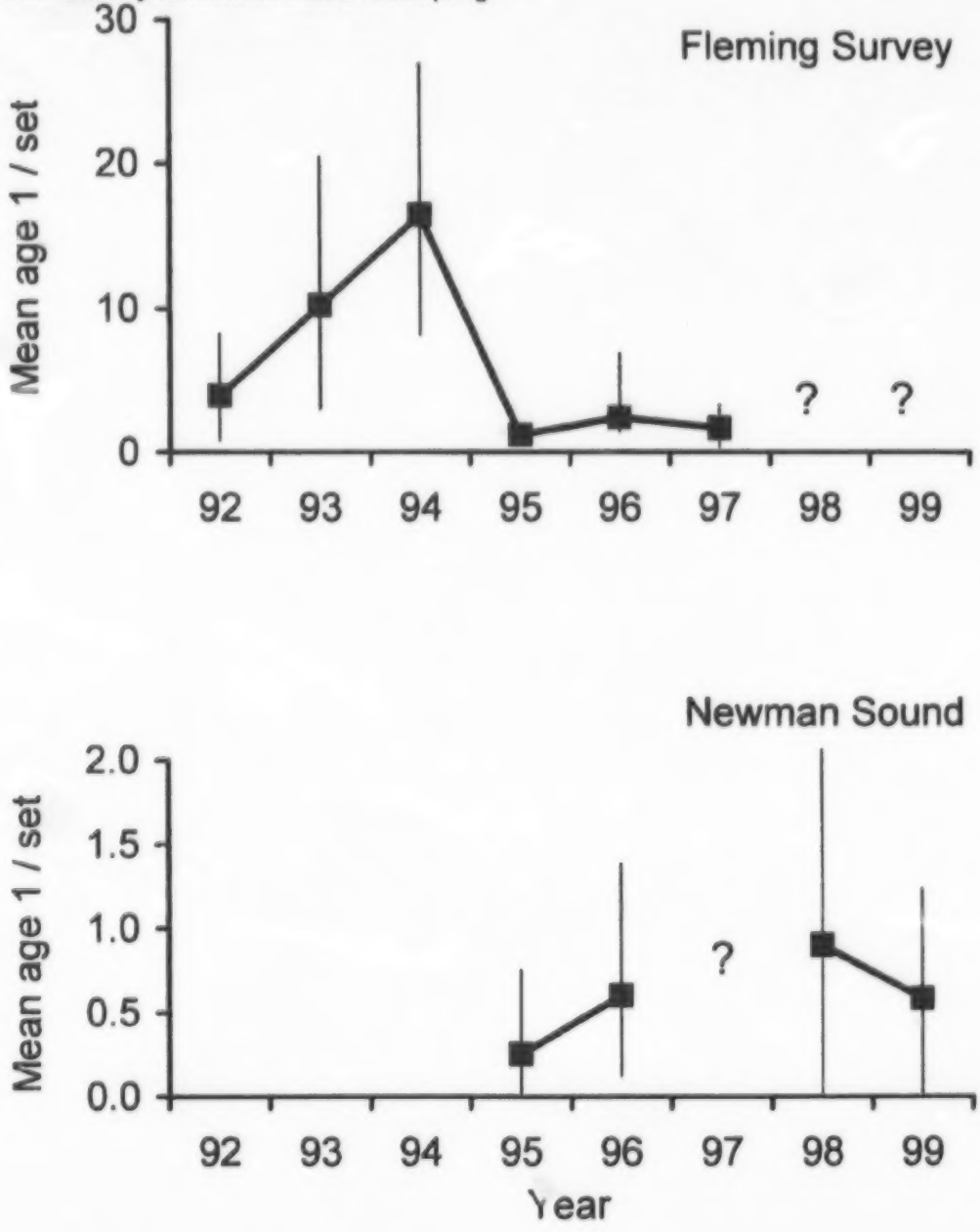

Figure 4. Length frequency of age 0 Atlantic cod caught by nearshore beach seining in Newman Sound, Bonavista Bay, July - November 1996

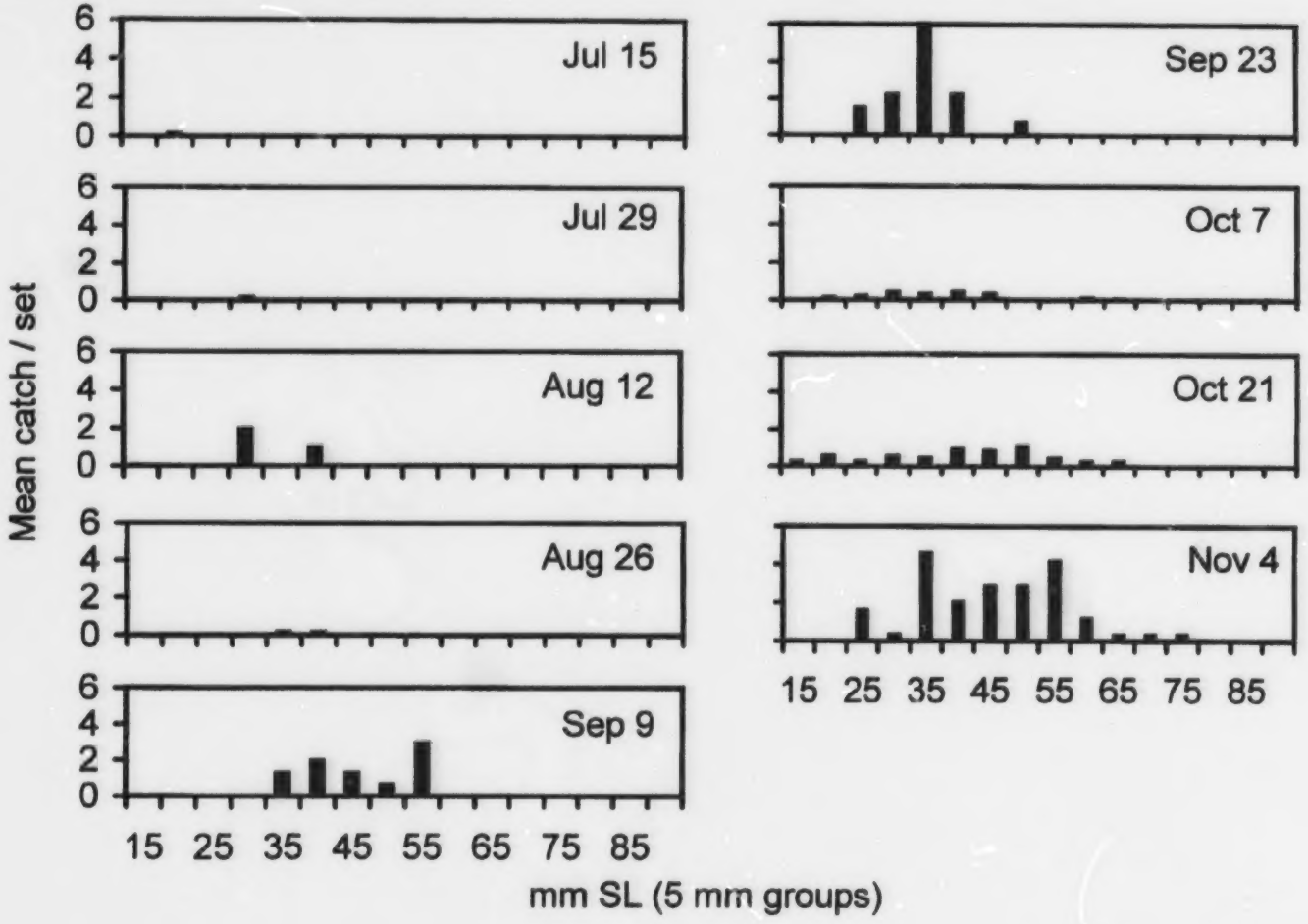

Figure 5. Length frequency of age 0 Atlantic cod caught by nearshore beach seining in Newman Sound, Bonavista Bay, July - November 1998.

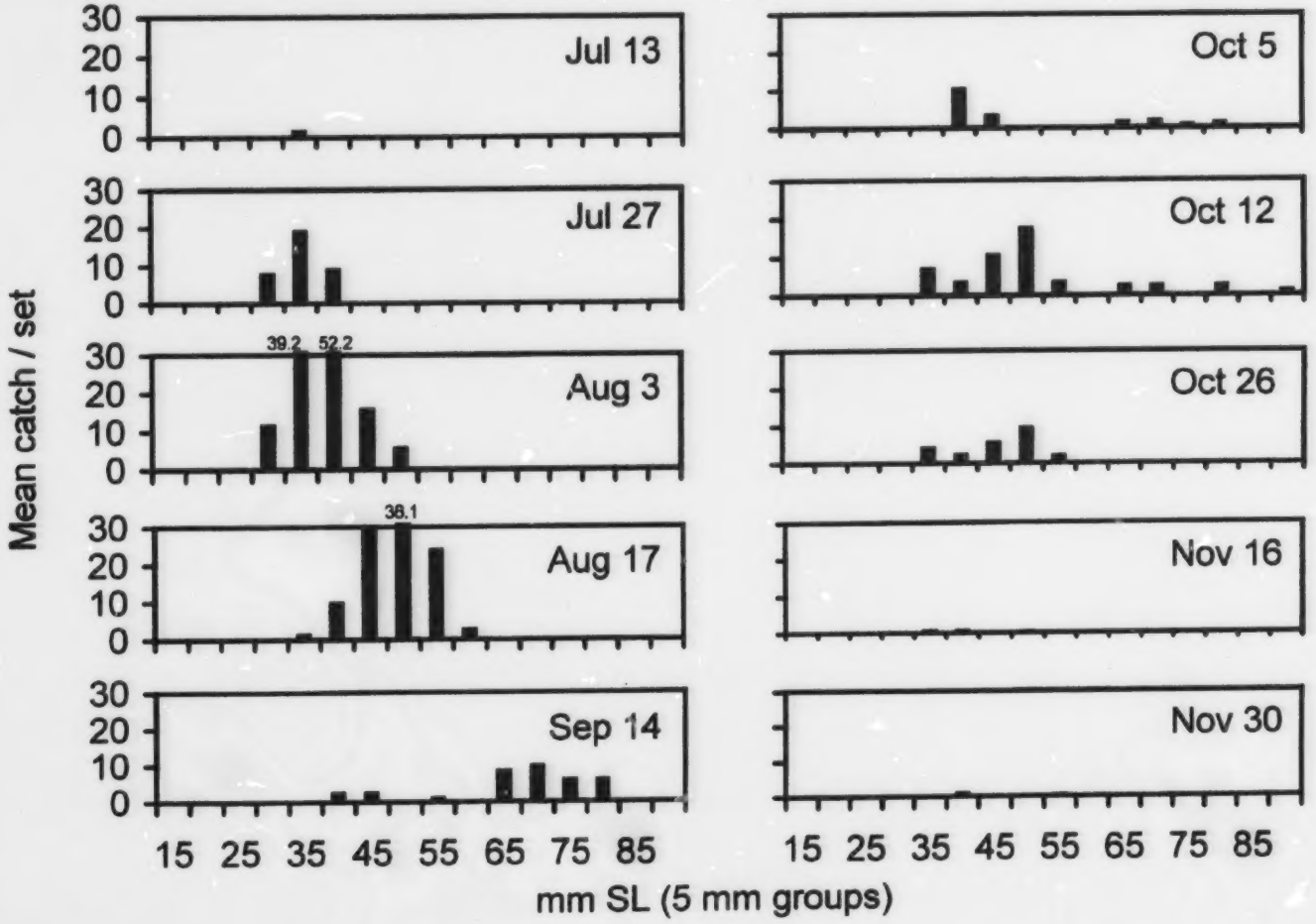

Figure 6. Length frequency of age 0 Atlantic cod caught by nearshore beach seining in Newman Sound, Bonavista Bay, July - November 1999.

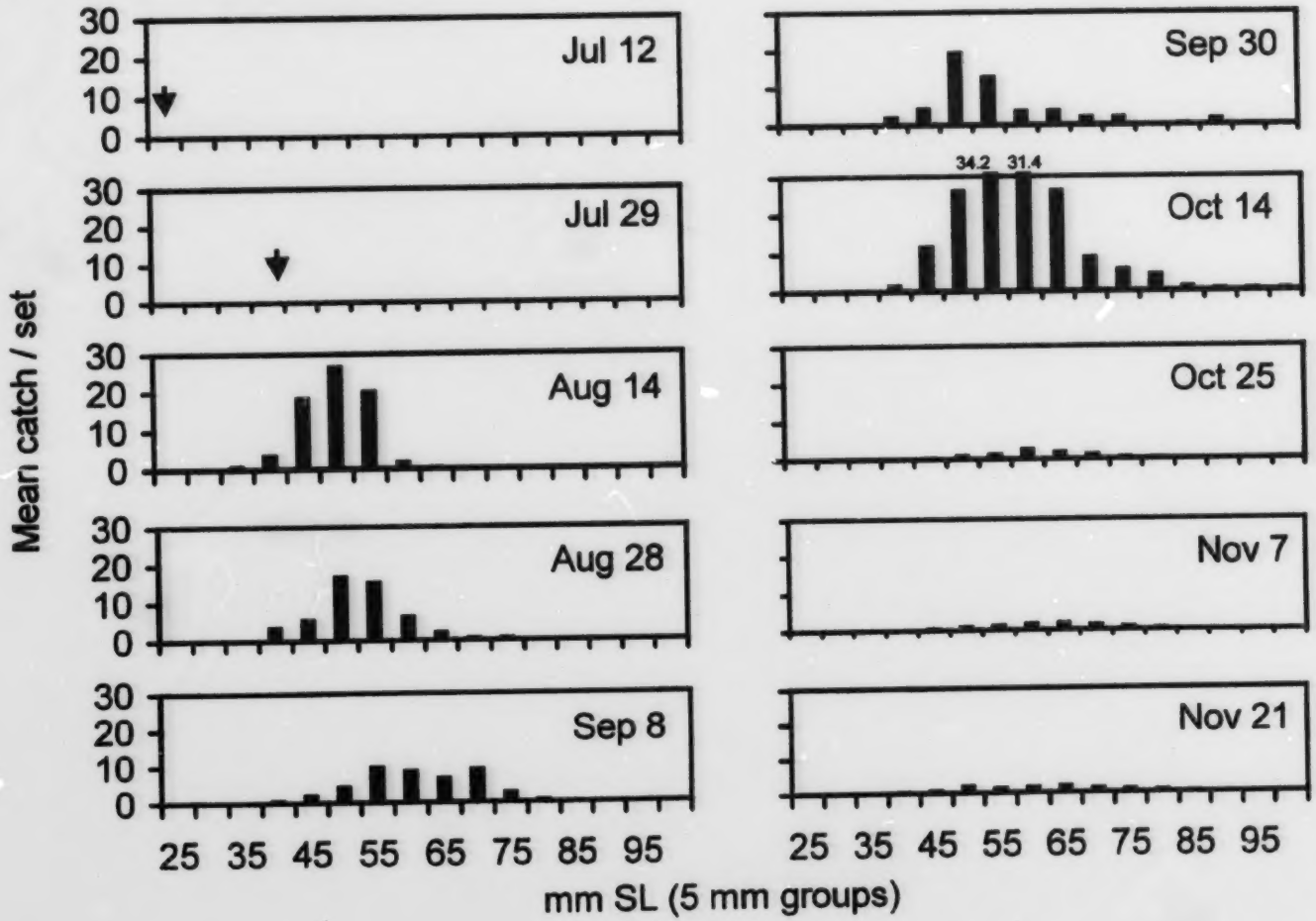

Figure 7. Sizes of Atlantic cod captured by beach seine in Newman Sound, Bonavista Bay, July - November, 1996 and their potential age and recruitment pulse structure.

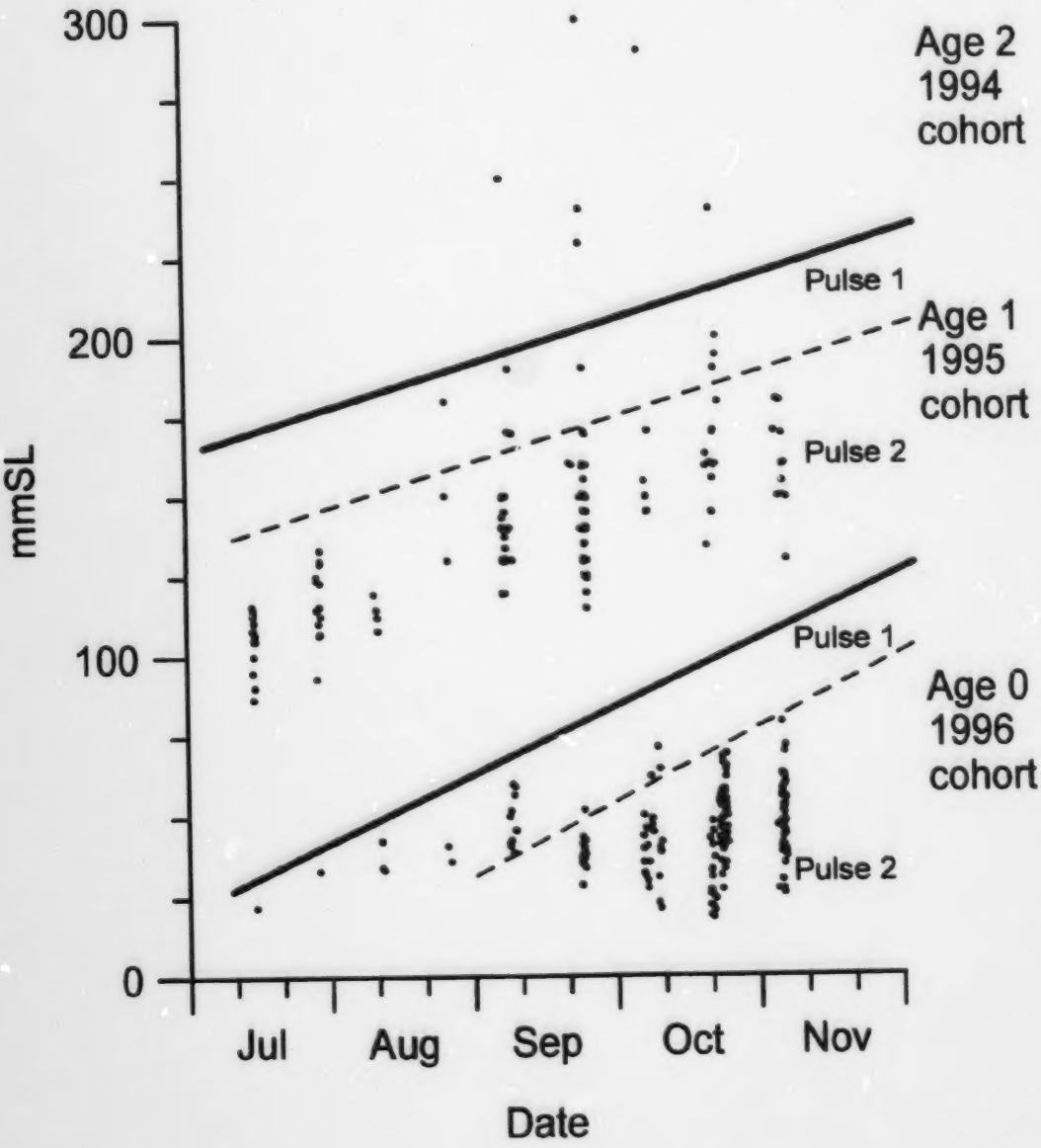

Figure 8. Sizes of Atlantic cod captured by beach seine in Newman Sound, Bonavista Bay, July - November, 1998 and their potential age and recruitment pulse structure.

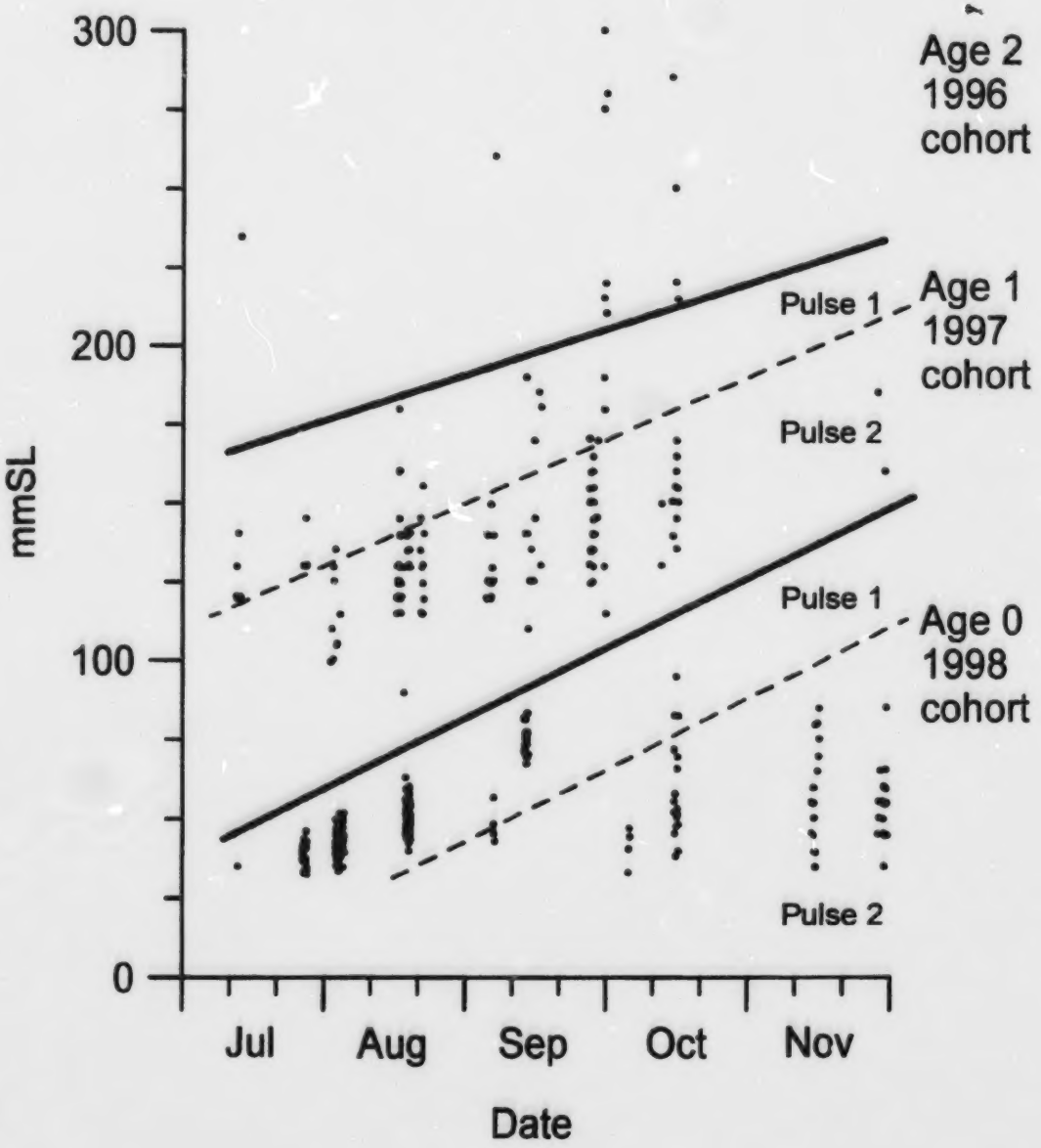

Figure 9. Sizes of Atlantic cod captured by beach seine in Newman Sound, Bonavista Bay, July - November, 1999 and their potential age and recruitment pulse structure.